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DIODE

STEP STRESS TESTING PROGRAM

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FINAL REPORT
FOR

JANTX 1N5420

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Prepared
For

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FOREWORD

This report is a summary of the work performed on NASA Contract NAS8-31944. The investigation was conducted for the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama. The Contracting Officer's Technical Representative was Mr. F. Villella.

The short term objective of this preliminary study of transistors, diodes, and FETs was to evaluate the reliability of these discrete devices, from different manufacturers, when subjected to power and temperature step stress tests.

The long term objective will be to gain more knowledge of accelerated stress testing for use in future testing of varieties of discrete devices, as well as to determine which type of stress should be applied to a particular type of device or design.

This report is divided as follows: description of tests, figures, tables, and appendix.

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1.0 INTRODUCTION/SCOPE

DCA Reliability Laboratory, under Contract NAS8-31944 for NASA/Marshall Space Flight Center, has compiled data for the purpose of evaluating the effect of power/temperature step stress when applied to a variety of semiconductor devices. This report covers the diode JANTX1N5420 manufactured by Unitrode and Micro-Semiconductor.

1.1 Sample Distribution

A total of 48 samples from each manufacturer were submitted to the process outlined in Table I. In addition, two control sample units were maintained for verification of the electrical parametric testing.

2.0 TEST REQUIREMENTS

2.1 Electrical

All test samples were subjected to the electrical tests outlined in Table II after completing the prior power/temperature step stress point. These tests were performed using the Fairchild Model 600 High-Speed Computer-Controlled Test System. In addition, some bench testing was also required on the devices.

2.2 Stress Circuit

The test circuit shown in Figure 1 was used to power all of the test devices during the power/temperature stress conditions. The voltage was set by V_F, and the current was varied in order to comply with the specified power rating for this device.

At least one of the devices was subjected to maximum rated power (MRP). All the remaining devices were subjected to no less than 90 percent of MRP. See Figure 1 for load resistance values and voltages.

2.3 Group I – Power Stress

Thirty-two units, 16 from each manufacturer, were submitted to the power stress process. The diodes were stressed in 500-hour steps at 50, 100, 125, 150 and 175 percent of MRP for a total of 2500 hours, or until 50 percent or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each power step. See Table I.

2.4 Group II – Temperature Stress I

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress I process. Group II was subjected to a total of 1600 hours of stress at MRP in increments of 160 hours. The temperature was increased in steps of +25°C, commencing at +75°C and terminating at +300°C or until 50 percent or more of the devices failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. (See Table I.)

2.5 Group III – Temperature Stress II

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress II process. Group III

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*Conditions for failure:

A) Open or short
B) Leakage exceeds the maximum limit by 100 times
C) Other parameters exceed MIL limits by 50 percent or greater

was subjected to 112 hours of stress total at MRP in increments of 16 hours with temperature steps of +25°C commencing at +150°C and terminating at +300°C or until 50 percent or more of the devices in a sample lot failed at a point in the testing.* Electrical measurements were performed on all specified electrical parameters after each temperature step. (See Table I.)

3.0 DISCUSSION OF TEST RESULTS

3.1 Group I - Power Stress

3.1.1 Unitrode. The Unitrode sample lot completed 1025 hours total before the lot was stopped because of more than 50 percent of the devices failing at this point. The first two failures occurred 50 hours into the 100 percent MRP step. Serial Number 1820 failed because of excessive I_R leakage. Serial Number 1822 was removed from the testing as a visual reject because of the anode lead detaching. The next failure occurred 150 hours into the 100 percent MRP step. Serial Number 1830 failed the minimum V_{F1} and V_{F2} limits. The last of the failures occurred 10 hours into the 125 percent MRP step. Serial Numbers 1818, 1821, 1824, 1827 and 1828 were removed as visual rejects because of the anode leads detaching due to stress. Serial number 1823 failed the minimum V_{F1} and V_{F2} limits. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 6.18μA from an initial mean of 181.3nA to a final mean of 6.362μA.

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*Conditions for failure:

A) Open or short
B) Leakage exceeds the maximum limit by 100 times
C) Other parameters exceed MIL limits by 50 percent or greater

2) The mean value for V_{F1} changed 408.3mV from an initial mean of 1.271V to a final mean of 862.7mV.
3) The mean value for V_{F2} changed 209.3mV from an initial mean of 924.3mV to a final mean of 715.0mV.

The control units for this sample lot remained constant throughout the entire Group I testing.

3.1.2 Micro-Semiconductor. The MSC sample lot completed a total of 1550 hours before the lot was stopped because of a failure rate that exceeded 50 percent of the lot. The first failure occurred 10 hours into the 150 percent MRP step. Serial Number 1768 failed because of excessive I_R leakage. The next failures occurred 25 hours into the 150 percent MRP step. Serial Number 1767 failed because of excessive I_R leakage. Serial Number 1770 was removed as a visual reject because the anode lead detached. The last five failures occurred 50 hours into the 150 percent MRP step. Serial Numbers 1769, 1773, 1774, 1775 and 1776 were removed as visual rejects because the anode leads detached. Typical characteristics of this lot's performance were:

1) The mean value for I_R changed 52.1nA from an initial mean of 387.6nA to a final mean of 439.7nA.
2) The mean value for V_{F1} changed 18.0mV from an initial mean of 1.095V to a final mean of 1.113V.
3) The mean value for V_{F2} changed 9.1mV from an initial mean of 906.2mV to a final mean of 915.3mV.

The control units for this sample lot remained constant throughout the entire Group I testing.

3.1.3 Statistical Summary - Group I. Table IV outlines the results of Group I - Power Stress process for each of the three electrical parameters and all measurement points for both Unitrode and Micro-Semiconductor.

3.2 Group II - Temperature Stress I

3.2.1 Unitrode. The Unitrode sample lot completed 320 hours before the lot was stopped because of a failure rate that exceeded more than 50 percent of the lot. The first six failures occurred 160 hours into the +75°C temperature step. Serial Numbers 1837, 1839, 1842, 1843 and 1845 failed because of excessive I_R leakage. Serial Number 1838 was removed from the testing as a visual reject because the anode lead detached. The last failures occurred 160 hours into the +100°C temperature step. Serial Numbers 1834 and 1841 failed the minimum V_{F2} limit. Serial Number 1835 failed the maximum V_{F1} limit. Typical characteristics of this lot's performance were:

1) The mean value for I_R changed 104.26µA from an initial mean of 141.6nA to a final mean of 104.4µA.

2) The mean value for V_{F1} changed 320.0mV from an initial mean of 1.252V to a final mean of 1.572V.

3) The mean value for V_{F2} changed 454.0mV from an initial mean of 907.0mV to a final mean of 1.361V.

The control units for this sample lot remained constant throughout the Group II testing.

3.2.2 Micro-Semiconductor. The MSC sample lot completed the entire 1600-hour Group II testing with no catastrophic failures. Typical characteristics of this sample lot's

performance were:

1) The mean value for I_R changed 7.496µA from an initial mean of 417.0nA to a final mean of 7.913µA.

2) The mean value for V_{F1} changed 12.0mV from an initial mean of 1.083V to a final mean of 1.095V.

3) The mean value for V_{F2} changed 1.4mV from an initial mean of 916.9mV to a final mean of 915.5mV.

The control units for this sample lot remained constant throughout the entire Group II testing.

3.2.3 Statistical Summary - Group II. Table V of this report outlines the results of Group II - Temperature Stress I testing for each of the three electrical parameters and all of the measurement points pertaining to both Unitrode and Micro-Semiconductor.

3.3 Group III - Temperature Stress II

3.3.1 Unitrode. The Unitrode sample lot completed 48 hours before the lot was stopped because of a failure rate exceeding 50 percent of the lot. The first failures occurred 16 hours into the +150°C temperature step. Serial Numbers 1851, 1854, 1855, 1857, 1860 and 1863 were removed as visual rejects because the anode leads detached. Serial Number 1858 failed because of excessive I_R leakage. The last failure occurred 16 hours into the +200°C temperature step. Serial Number 1853 was removed from the testing because the anode detached. Typical characteristics of this lot's performance were:

1) The mean value for I_R changed 5.25µA from an initial mean of 196.9nA to a final mean of 5.448µA.

2) The mean value for V_{F1} changed 54.0mV from an initial mean of 1.162V to a final mean of 1.108V.

3) The mean value for V_{F2} changed 7.1mV from an initial mean of 910.3mV to a final mean of 903.2mV.

The control units for this sample lot remained constant throughout the Group III testing.

3.3.2 Micro-Semiconductor. The MSC sample lot completed the entire 112-hour Group III testing with no catastrophic failures. Typical characteristics of this lot's performance were:

1) The mean value for I_R changed 619.8nA from an initial mean of 430.2nA to a final mean of 1.05μA.

2) The mean value for V_{F1} changed 17.0mV from an initial mean of 1.092V to a final mean of 1.109V.

3) The mean value for V_{F2} changed 3.0mV from an initial mean 908.5mV to a final mean of 911.5mV.

The control units for this sample lot remained constant throughout the entire Group III testing.

3.3.3 Statistical Summary - Group III. Table VI outlines the results of Group III - Temperature Stress II testing for each of the three electrical parameters specified for this job lot.

4.0 FINAL DATA SUMMARY

Table VII summarizes the change in the mean value from the zero-hour data to the final data. The graphs of Figures 2 and 3 plot the cumulative percent failures versus the temperature stress level for Group II - Temperature Stress I, and Group III - Temperature Stress II. Tables VIII and IX summarize the failures encountered

from all three stress groups. The test devices are separated into two groups: catastrophic failures in Table VIII and parametric failures in Table IX. The data from Table VIII was used as a source for the graphs in Figures 2 through 4.

5.0 CONCLUSIONS

Taking an over-all look at the three stress groups, it can clearly be seen that the Micro Semiconductor diode is a much more durable diode when compared to the Un··ode diode. Although both manufacturers' lots had to be stopped in the Group I - Power Stress testing, note that the Micro Semiconductor lot continued processing 500 hours further into the testing. Unitrode had to be stopped early into both of the Temperature Stress Group testing but Micro Semiconductor completed the entire Group II and Group III testing without a single catastrophic failure.

Failure analysis was performed on the Group II testing only because of an apparent failure mode throughout the three stress groups. By far the majority of catastrophic failures was due to the anode lead, on the Unitrode devices, detaching and falling off. Failure analysis points out that the design of the Micro Semiconductor device includes a shaped junction edge which is lacking in the Unitrode part. Junction shaping is a recognized technique which causes the breakdown stress to be shifted into the bulk of the semiconductor and away from the leakage on the surface. This approach has often been successful in significantly increasing breakdown voltages and reducing leakage.

A graph showing cumulative failure distribution for Group II and III testing was plotted for the Unitrode sample lot (Figure 2 and 3) but due to an absence of main failure points in both groups, the regression lines could not be drawn. A plot for the Micro Semiconductor sample lot could not be drawn due to an absence of failure points in the Group II and III testing (Figure 4 and 5). For the same reasons, no activation energies could be calculated.

A broken circle around a marked point on the graphs indicates a freak failure not calculated as part of the regression line. A solid circle around a marked point indicates an isolated failure point. The regression line was calculated using the least square method.

The activation energy was calculated from the formula:

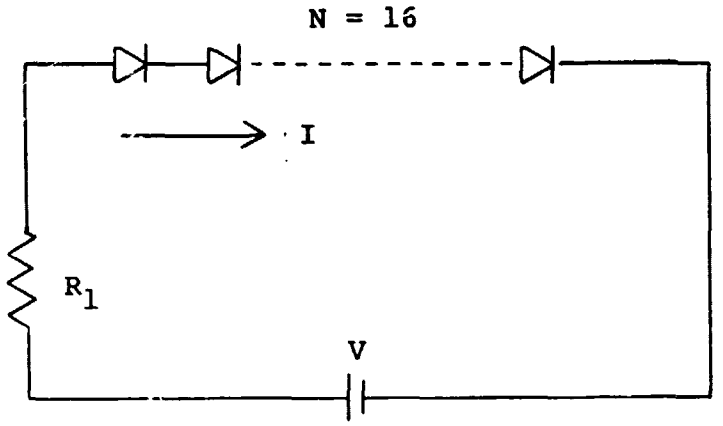
$$E = \left[\ell n \left(\frac{t_1}{t_2} \right) \right] \left[\frac{8.63 \times 10^{-5} \text{ eV/}^{\circ}\text{K}}{\left(\frac{1}{T_1 + 273} \right) - \left(\frac{1}{T_2 + 273} \right)} \right] \text{eV}$$

Where: t_1 = step of Group II - Temp Stress I = 160 hrs.

t_2 = step of Group III - Temp Stress II = 16 hrs.

T_1 = temperature in $^{\circ}$C of 16% failure for Group II.

T_2 = temperature in $^{\circ}$C of 16% failure for Group III.

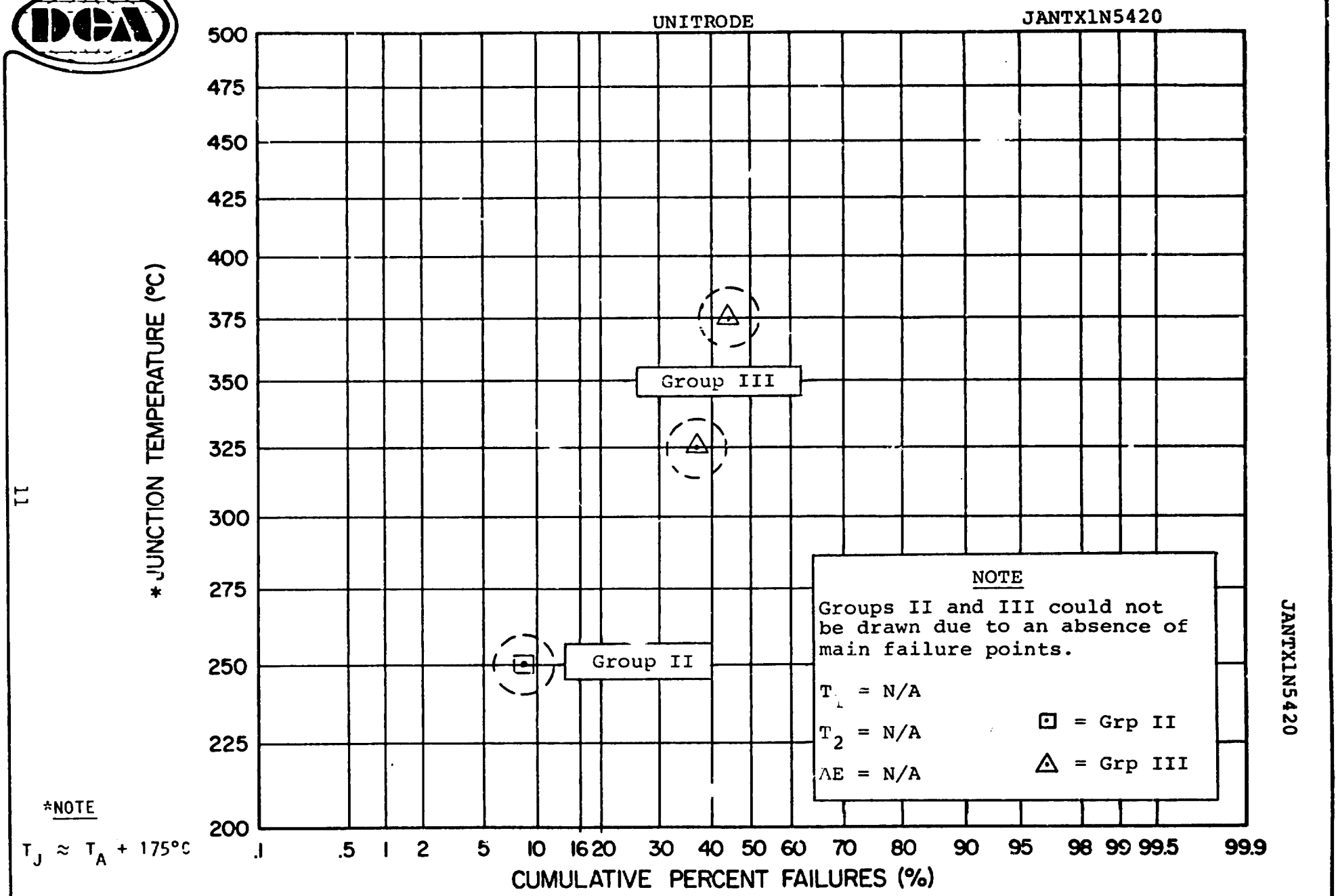


$R_1 = 1V/_I \pm 1\%$

$P_d = I\,E$

FIGURE 1

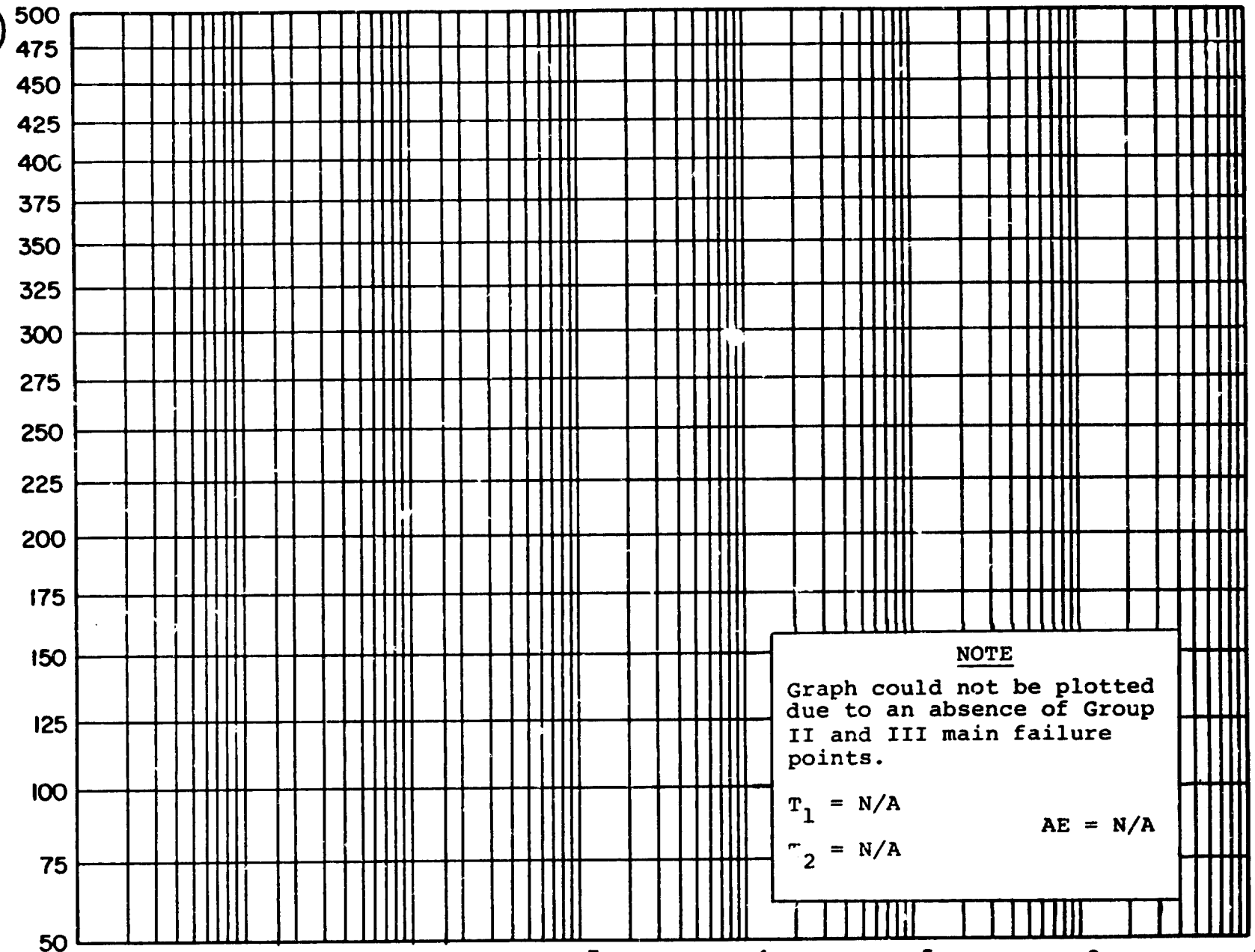
Power and Temperature Stress Circuit for JANTX1N5420



*NOTE

$T_J \approx T_A + 175°C$

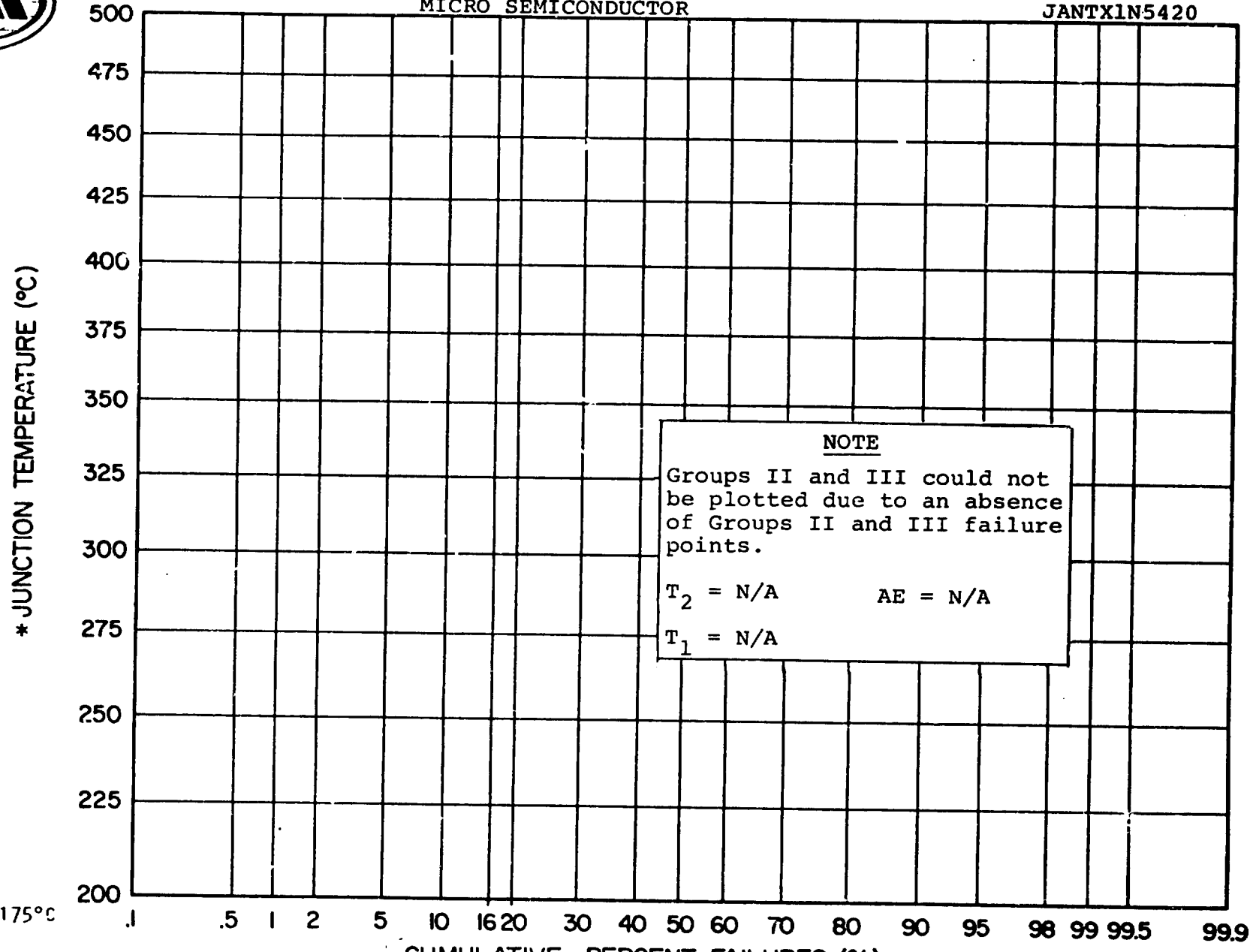
FIGURE 2
Cumulative Percent Failures Versus Junction Temperature, Unitrode



*NOTE

$T_J \approx T_A + 175°C$

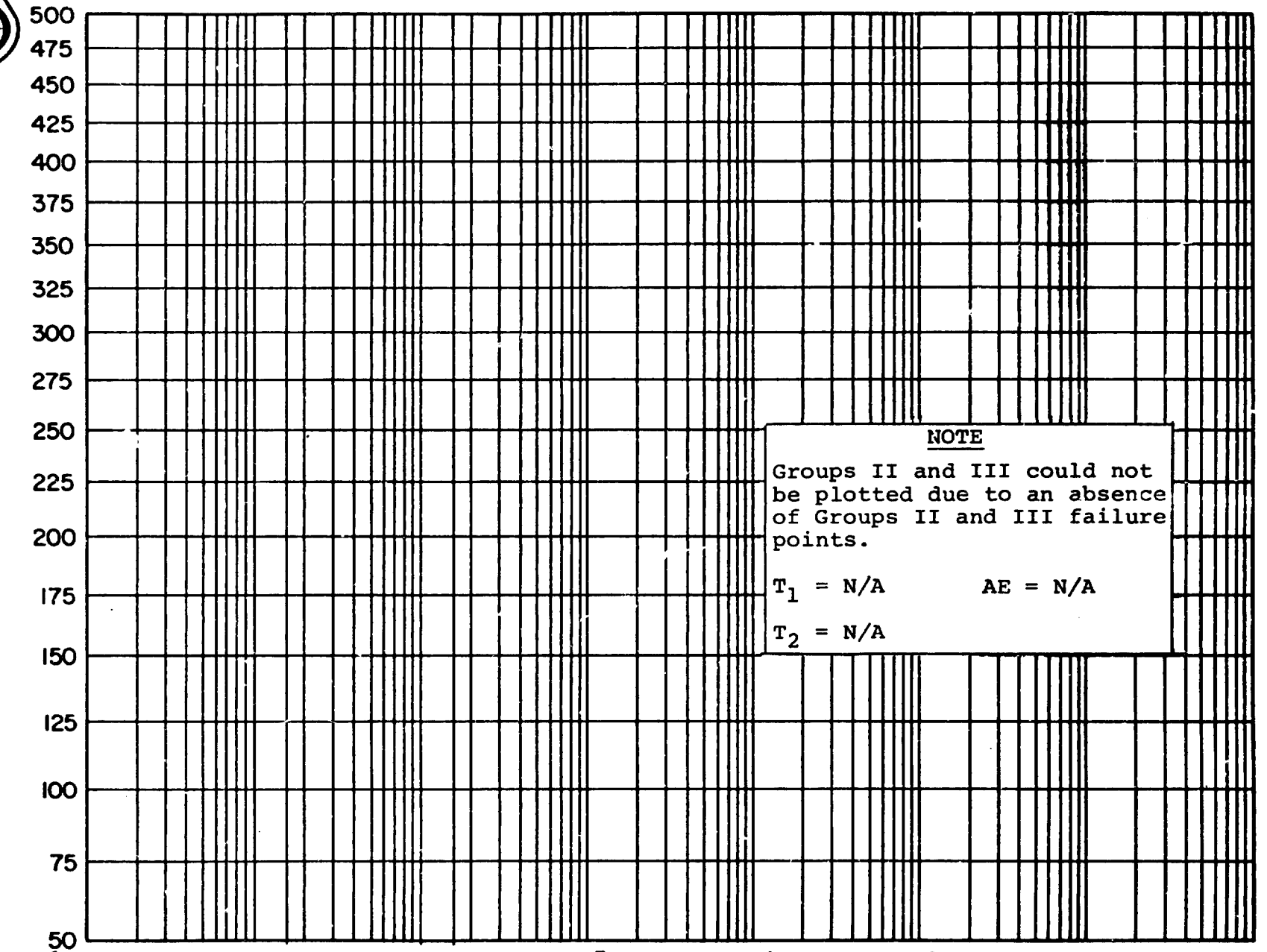
FIGURE 3
Time Steps Versus Junction Temperature, Unitrode



*NOTE

$T_J \approx T_A + 175°C$

FIGURE 4
Cumulative Percent Failures Versus Junction Temperature, Micro Semiconductor



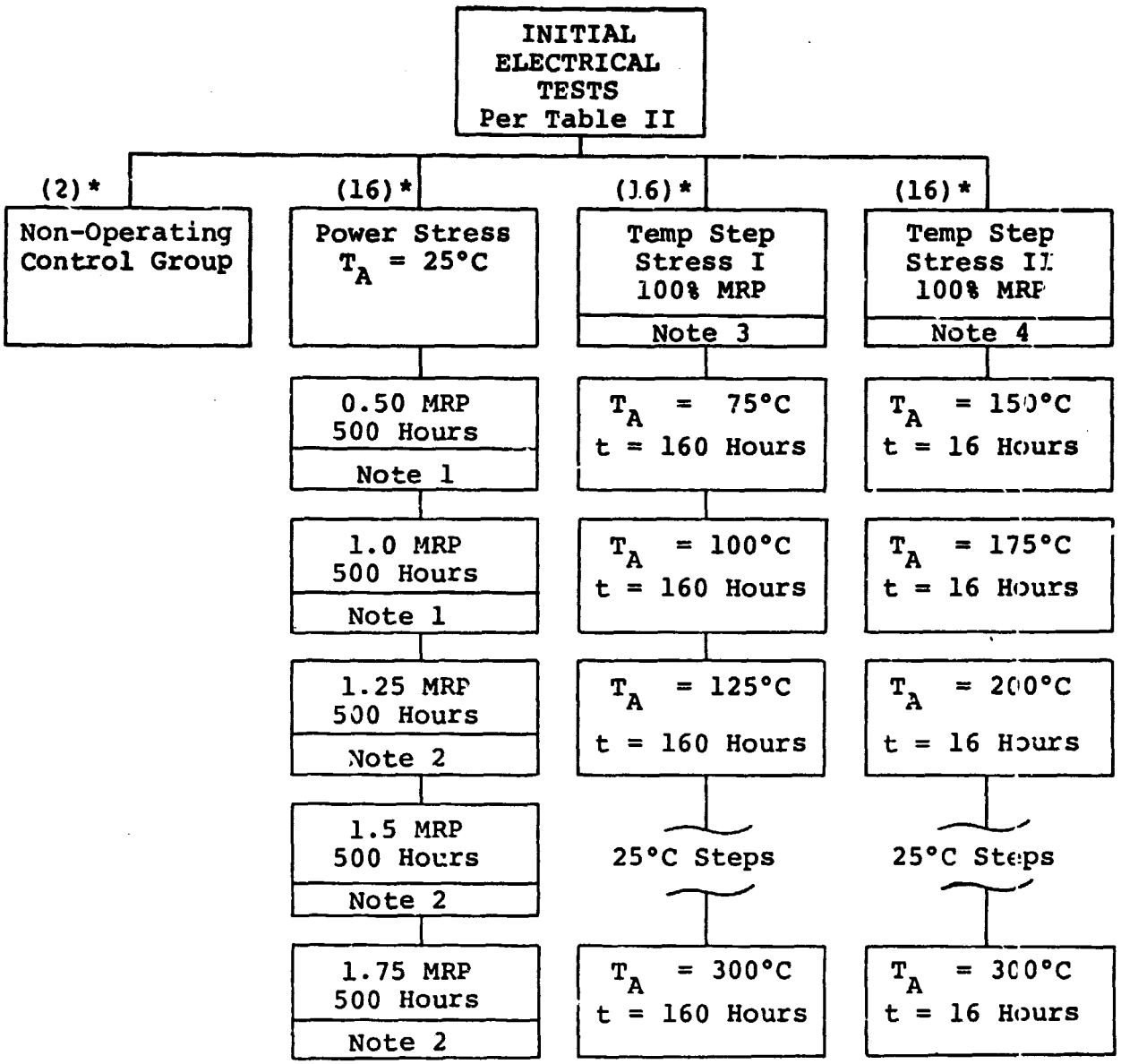
*NOTE

$T_J \approx T_A + 175°C$

FIGURE 5

Time Steps Versus Junction Temperature, Micro Semiconductor

TABLE I
TEST FLOW DIAGRAM



*Quantity per manufacturer (Unitrode and Micro-Semiconductor)

NOTES:

1) Electrical measurements per Table II were made at 50, 150, 250 and 500 hours.
2) Electrical measurements per Table II were made at 10, 25, 50, 150, 250 and 500 hours.
3) Electrical measurements per Table II were made at the end of each 160 hours.
4) Electrical measurements per Table II were made at the end of each 16 hours.

TABLE II
PARAMETERS AND TEST CONDITIONS

PARAMETER	CONDITIONS	SPEC. LIMIT		CAT. LIMIT[1]		UNITS
		MIN	MAX	MIN	MAX	
I_R	V_R = 600V	—	1.0	—	100.00	µA
V_{F1}	I_F = 9A (Pulsed)	0.6	1.5	0.3	2.25	V
V_{F2}	I_o = 2A (Not Pulsed)	0.6	1.2	0.3	1.80	V

NOTES:
1) In addition, any open or short shall be considered catastrophic.

TABLE III
POWER STRESS BURN-IN CONDITIONS

V_F = 1.0V	
I_F	Percent P_D
1.8A	50
3.6A	100
4.5A	125
5.4A	150
6.3A	175

NOTE

FOR TABLES

4 THROUGH 7

The minimum/maximum initial and final data generally have an absolute accuracy of ±1% of the reading and ± one digit except for readings greater than 9.99mA which have an absolute accuracy of ±2% of the reading and ± one digit. The data also has a resolution for four digits. The standard deviations, means, delta means, and average means are, therefore, valid indicators of trends over time and temperature, excepting the minor statistical computer error of supplying a constant number of significant digits.

TABLE IV
GROUP I — POWER STRESS DATA SUMMARY
(160 Hour Power Stress)

PARAMETER	I_R = 1.0μA (max)		V_{F1} = 0.6V (min) 1.5V (max)		V_{F2} = 0.6V (min) 1.2V (max)			
CONDITIONS AND LIMIT	V_R = 600V		I_F = 9A (Pulsed)		I_0 = 2A (Not Used)			
IDENTIFICATION	UNITRODE	MICRO SEMI-CONDUCTOR	UNITRODE	MICRO SEMI-CONDUCTOR	UNITRODE	MICRO SEMI-CONDUCTOR		
INITIAL DATA								
MIN VALUE	120.00nA	318.00nA	1.16000V	1.08000V	886.2mV	895.400mV		
MAX VALUE	265.00nA	504.00nA	1.44000V	1.13000V	973.3mV	922.700mV		
MEAN	181.30nA	387.60nA	1.27100V	1.09500V	924.3mV	906.200mV		
STD DEV	42.93nA	56.27nA	0.07615V	0.01414V	25.6mV	6.719mV		
INTERIM DATA								
POWER 50 TO 125% Δ MEAN VALUE								
50% POWER								
50 hrs	- 10.9nA	-56.6nA	3.0mV	7.0mV	0.3mV	0.7mV		
150 hrs	- 6.1nA	-46.1nA	- 60.0mV	12.0mV	- 5.5mV	12.2mV		
250 hrs	126.4nA	-88.9nA	- 97.0mV	1[illegible].0mV	- 8.5mV	13.2mV		
500 hrs	628.1nA	-19.2nA	-118.0mV	19.0mV	-12.3mV	11.8mV		
100% POWER								
550 hrs	30.37μA	- 83.3nA	-170.0mV	20.0mV	-18.8mV	10.7mV		
650 hrs	13.89μA	- 80.5nA	-236.0mV	14.0mV	-73.6mV	10.6mV		
750 hrs	9.14μA	- 65.7nA	-250.0mV	21.0mV	-77.7mV	10.9mV		
1000 hrs	13.10μA	-112.9nA	-243.0mV	9.0mV	-75.4mV	12.2mV		
125% POWER								
1010 hrs	6.23μA	-65.5nA	-444.7mV	15.0mV	- 98.0mV	9.6mV		
1025 hrs	6.18μA	-77.8nA	-408.3mV	11.0mV	-209.3mV	3.0mV		
1050 hrs	JOB STOPPED	-60.8nA	JOB STOPPED	21.0mV	JOB STOPPED	11.2mV		
1150 hrs	↓	-51.7nA	↓	19.0mV	↓	13.2mV		
1250 hrs	↓	-52.4nA	↓	19.0mV	↓	7.6mV		
1500 hrs	↓	-84.0nA	↓	-65.0mV	↓	- 4.0mV		

(continued on second sheet)

TABLE IV (Cont'd)

(continued from first sheet) GROUP I – POWER STRESS DATA SUMMARY

PARAMETER	I_R = 1.0µA (max)		V_{F1} = 0.6V (min) 1.5V (max)		V_{F2} = 0.6V (min) 1.2V (max)			
CONDITIONS AND LIMITS	V_R = 600V		I_F = 9A (Pulsed)		I_O = 2A (Not Pulsed)			
IDENTIFICATION	UNITRODE	MICRO SEMI-CONDUCTOR	UNITRODE	MICRO SEMI-CONDUCTOR	UNITRODE	MICRO SEMI-CONDUCTOR		
INITIAL DATA								
MIN VALUE	120.00nA	318.00nA	1.16000V	1.08000V	886.2mV	895.400mV		
MAX VALUE	265.00nA	504.00nA	1.44000V	1.13000V	973.3mV	922.700mV		
MEAN	181.30nA	387.60nA	1.27100V	1.09500V	924.3mV	906.200mV		
STD DEV	42.93nA	56.27nA	0.07615V	0.01414V	25.6mV	6.719mV		
INTERIM DATA								
POWER 150 TO 175% Δ MEAN VALUE								
150% POWER								
1510 hrs		142.6µA		13.0mV		8.30mV		
1525 hrs		713.6µA		10.0mV		9.90mV		
1550 hrs		-52.1nA		18.0mV		9.10mV		
1650 hrs		JOB STOPPED		JOB STOPPED		JOB STOPPED		
1750 hrs								
2000 hrs								
175% POWER								
2010 hrs	↓	↓	↓	↓	↓	↓		
2025 hrs								
2050 hrs								
2150 hrs								
2250 hrs								
2500 hrs								
FINAL DATA								
MIN VALUE	134.000nA	290.0nA	0.0000V	1.09000V	0.00V	900.00mV		
MAX VALUE	34.100µA	636.0nA	1.2500V	1.13000V	946.00mV	928.00mV		
MEAN	6.362µA	439.7nA	0.8627V	1.11300V	715.00mV	915.30mV		
STD DEV	11.300µA	120.8nA	0.4512V	0.01639V	367.80mV	10.12mV		

NOTE: Catastrophic Rejects removed from data.

TABLE V
GROUP II – TEMPERATURE STRESS SUMMARY DATA

PARAMETERS	I_R = 1.0μA (max)		V_{F1}=0.6V(min) 1.5V(max)		V_{F2}=0.6V(min) 1.2V(max)	
CONDITIONS AND LIMITS	V_R = 600V		I_F = 9A (Pulsed)		I_0 = 2A (Not Pulsed)	
IDENTIFICATION	UNITRODE	MICRO SEMI-CONDUCTOR	UNITRODE	MICRO SEMI-CONDUCTOR	UNITRODE	MICRO SEMI-CONDUCTOR
INITIAL DATA						
MIN VALUE	45.50nA	323.00nA	1.16000V	1.05000V	892.00mV	897.00mV
MAX VALUE	265.00nA	529.00nA	1.40000V	1.11000V	931.00mV	935.00mV
MEAN	141.60nA	417.00nA	1.25200V	1.08300V	907.00mV	916.90mV
STD DEV	66.32nA	57.53nA	0.06729V	0.01648V	11.21mV	10.16mV
INTERIM DATA (INITIAL TO FINAL)						
Δ MEAN VALUE						
Total Hrs / Temperature (T_A)						
160 / 75°C	328.25μA	- 9.500nA	-141.0mV	33.0mV	- 0.2mV	- 0.1mV
320 / 100°C	104.26μA	-23.900nA	-320.0mV	35.0mV	454.0mV	2.6mV
480 / 125°C	JOB STOPPED	28.700nA	JOB STOPPED	36.0mV	JOB STOPPED	3.1mV
640 / 150°C		80.400nA		28.0mV		3.4mV
800 / 175°C		770.000nA		28.0mV		2.9mV
960 / 200°C		5.212μA		22.0mV		6.1mV
1120 / 225°C		8.108μA		30.0mV		7.7mV
1280 / 250°C		3.509μA		39.0mV		7.5mV
1440 / 275°C		8.852μA		18.0mV		2.1mV
1600 / 300°C		7.496μA		12.0mV		- 1.4mV
FINAL DATA						
FINAL TEMP (T_A)	100°C	300°C	100°C	300°C	100°C	300°C
MIN VALUE	754.0nA	3.210μA	0.000V	1.07000V	0.000V	900.000mV
MAX VALUE	969.0μA	11.700μA	8.500V	1.13000V	8.640V	933.000mV
MEAN	104.4μA	7.913μA	1.572V	1.09500V	1.361V	915.500mV
STD DEV	273.9μA	2.256μA	2.218V	0.01658V	2.327V	9.327mV

NOTE: Catastrophic rejects removed from data.

TABLE VI
GROUP III - TEMPERATURE STRESS SUMMARY DATA

PARAMETERS	I_R = 1.0μA (max)		V_{F1} = 0.6V(min)1.5V(max)		V_{F2} = 0.6(min) 1.2V(max)	
CONDITIONS AND LIMITS	V_R = 600V		I_F = 9A (Pulsed)		I_0 = 2A (Not Pulsed)	
IDENTIFICATION	UNITRODE	MICRO SEMI-CONDUCTOR	UNITRODE	MICRO SEMI-CONDUCTOR	UNITRODE	MICRO SEMI-CONDUCTOR
INITIAL DATA						
MIN VALUE	105.00nA	335.00nA	1.08000V	1.07000V	895.00mV	896.000mV
MAX VALUE	526.00nA	536.00nA	1.26000V	1.10000V	939.00mV	920.000mV
MEAN	196.90nA	430.20nA	1.16200V	1.09200V	910.30mV	908.500mV
STD DEV	97.64nA	61.06nA	0.05388V	0.00950V	11.63mV	6.529mV
INTERIM DATA (INITIAL TO FINAL)						
Δ MEAN VALUE						
Total Hrs / Temperature (T_A)						
16 / 150°C	57.32μA	- 7.8nA	-32.0mV	11.0mV	2.5mV	-0.7mV
32 / 175°C	62.90μA	-52.5nA	-43.0mV	15.0mV	-0.6mV	1.1mV
48 / 200°C	5.25μA	-10.7nA	-43.0mV	11.0mV	-7.1mV	-1.9mV
64 / 225°C	JOB STOPPED	318.7nA	JOB STOPPED	2.0mV	JOB STOPPED	-2.2mV
80 / 250°C	↓	339.8nA	↓	2.0mV	↓	-2.9mV
96 / 275°C	↓	478.7nA	↓	-6.0mV	↓	0.4mV
112 / 300°C	↓	481.3nA	↓	17.0mV	↓	3.0mV
		NOTE: CATASTROPHIC REJECTS REMOVED FROM DATA				
FINAL DATA						
FINAL TEMP (T_A)	200°C	300°C	200°C	300°C	200°C	300°C
MIN VALUE	162.000nA	334.000nA	1.06000V	1.08000V	888.00mV	898.00mV
MAX VALUE	28.000μA	4.290μA	1.20000V	1.13000V	932.00mV	924.00mV
MEAN	5.448μA	1.050μA	1.10800V	1.10900V	903.20mV	911.50mV
STD DEV	9.681μA	945.600nA	0.03994V	0.01298V	12.35mV	7.08mV

TABLE VII
FINAL DATA SUMMARY

PARAMETER	SPECIFICATIONS LIMIT		UNITS	MEAN INT. DATA	AVERAGE Δ IN MEAN VALUE					
					POWER STRESS		TEMPERATURE STRESS I		TEMPERATURE STRESS II	
	MIN	MAX			UNITRODE	MICRO SEMI-CONDUCTOR	UNITRODE	MICRO SEMI-CONDUCTOR	UNITRODE	MICRO SEMI-CONDUCTOR
I_R	-	1.0	μA		+7.9648	+50.322	+216.26	+3.4023	+41.823	+.22107
V_{F1}	.6	1.5	V		-.20240	+.01053	+.08950	+.02810	-.04300	+.00743
V_{F2}	.6	1.2	V		-.05788	+.00884	+.22690	+.00339	-.00173	-.00046

NOTE: Catastrophic reject(s) removed from data.

TABLE VIII STEP STRESS CATASTROPHIC FAILURE SUMMARY JAN TX1N5420

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	---	0	---
100 hr.	0	---	0	---
100 hr.	0	---	0	---
250 hr.	0	---	0	---
100% 50 hr.	1 / 1	A / B	0	---
100 hr.	1	C	0	---
100 hr.	0	---	0	---
250 hr.	0	---	0	---
125% 10 hr.	5 / 1	B / C	0	---
15 hr.	0	---	0	---
25 hr.	JOB STOPPED		0	---
100 hr.			0	---
100 hr.			0	---
250 hr.			0	---
150% 10 hr.			1	A
15 hr.			1 / 1	A / B
25 hr.			5	B
100 hr.			JOB	STOP
100 hr.				
250 hr.				
175% 10 hr.				
15 hr.				
25 hr.				
100 hr.				
100 hr.				
250 hr.	↓	↓	↓	↓

GROUP II 160 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75° C	5 / 1	A / B	0	---
100° C	2 / 1	E / D	0	---
125° C	JOB STOPPED		0	---
150° C			0	---
175° C			0	---
200° C			0	---
225° C			0	---
250° C			0	---
275° C			0	---
300° C	↓	↓	0	---

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	1	A	0	---
175°C	0	---	0	---
200°C	0	---	0	---
225°C	JOB STOPPED		0	---
250°C			0	---
275°C			0	---
300°C	↓	↓	0	---

MFR A - UNITRODE

MFR B - MICRO-SEMICONDUCTOR

NOTES:

A) I_R > 100μA

B) Visual (other than handling)

C) V_{F1} and V_{F2} < 300mV

D) V_{F1} > 3V

E) V_{F2} < 0.3V

TABLE IX. STEP STRESS PARAMETRIC FAILURE SUMMARY JAN TX1N5420

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	1	A	0	-
250 hr.	0	-	0	-
100% 50 hr.	4	A	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	1	A	0	-
125% 15 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	JOB STOPPED		0	-
100 hr.			0	-
100 hr.			0	-
250 hr.			0	-
150% 10 hr.			1	A
15 hr.			0	-
25 hr.			0	-
100 hr.			0	-
100 hr.			JOB STOPPED	
250 hr.				
175% 10 hr.				
15 hr.				
25 hr.				
100 hr.				
100 hr.				
250 hr.				

GROUP II 160 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75°C	5	A	0	-
100°C	2 / 1	A / B	0	-
125°C	JOB STOPPED		1	A
150°C			0	-
175°C			6	A
200°C			8	A
225°C			0	-
250°C			1	A
275°C			0	-
300°C			0	-

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	6	B	0	-
175°C	1	A	0	-
200°C	2 / 1	A / B	0	-
225°C	JOB STOPPED		3	A
250°C			0	-
275°C			2	A
300°C			0	-

MFR A - UNITRODE

MFR B - MICRO-SEMICONDUCTOR

NOTES:

A) I_R Limit Failure

B) V_{F1} and V_{F2} Minimum Limit Failure

APPENDIX

- FAILURE ANALYSIS -

JANTX1N5420

MSFC STEP-STRESS TEST
FAILURE ANALYSIS — DIODES

Date 6 April 1978

J/N 2CN242-16C P/N 1N5420 MFR Micro-Semiconductor

FAILURE VERIFICATION:

S/N	PIV	I_r @ 600 Vdc Lim = 1.0μA	V_f @ 2Adc Lim = 1.2V				Initial Rej. @ Test Seq. No.:	Initial Rej. for:
1799	820	1.40μA	0.93				09	IR
1811	790	1.45μA	0.92				09	IR
1812	840	4.00μA	0.92				09	IR

INTERNAL VISUAL INSPECTION:

The samples have lost all of their external paint. No anomalies were visible in the cross section (Figure A-1).

OTHER TESTS:

All samples were treated with epoxy stripper and were given a very slight glass etch to remove any possible conductive layer which might have been left as a paint residue.

There was no significant change in the leakages.

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)

**h_{FE} trace very leaky.

D = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable

DCA

MSFC STEP-STRESS TEST
FAILURE ANALYSIS — DIODES

Date 6 April 1978

J/N 2CN242-16C P/N 1N5420 MFR Unitrode

FAILURE VERIFICATION:

S/N	PIV	I_r @ 600Vdc Lim = 1.0μA	V_f @ 2Adc Lim = 1.2V				Initial Rej. @ Test Seq. No.:	Initial Rej. for:
1853	630	<0.2μA	0.95				03	lead off
1855	560	80.0μA	0.99				03	lead off
1858	680†	500.0μA	0.95				03	IR
†Breakdown starts to become leaky at about 80V.								

INTERNAL VISUAL INSPECTION:

S/N 1853 and 1855 have each lost one wire at the joint between the wire and the anode heat sink. (See Figure A-3.) S/N 1853 has also lost all its paint. No anomalies were visible in the cross-section (Figure A-2).

OTHER TESTS:

The paint was removed from S/N 1858 with no change in the reverse leakage characteristics.

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)

**h_{FE} trace very leaky.

D = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable

CONCLUSIONS

The design of the Micro Semiconductor device includes a shaped junction edge which is lacking in the Unitrode part. (See Figures A-1 and A-2.) Junction-shaping is a recognized technique which causes the breakdown stress to be shifted into the bulk of the semiconductor and away from the leakage on the surface. This approach has often been successful in significantly increasing breakdown voltages and reducing leakage.

UNITRODE

Seven Unitrode devices out of 16 fell apart during burn-in at 150°C ambient. Six of the seven separations were at the anode lead.

The reverse leakage of Unitrode S/N 1858 and 1855 undergoes a stepwise increase as the voltage is raised above about 80 volts and 200 volts, respectively.

The curve tracer displays are stable and suggest junction damage rather than surface problems. The exact cause of this damage is not known, but may be a result of aggregation of gold doping which may have been used in the manufacture of the Unitrode wafers.

MICRO-SEMICONDUCTOR

I_R is in the 1 to 4 microamp range and is considered to be the result of contaminants diffused to the junction region from the package components.

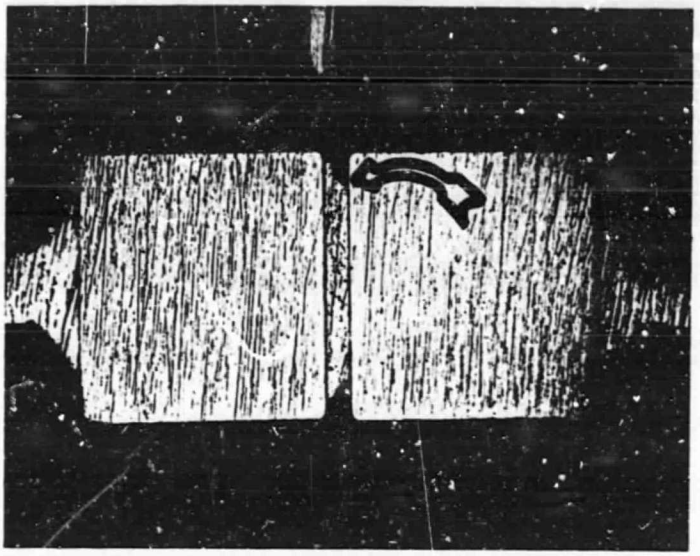


FIGURE A-1
S/N 1812. MAGNIFICATION 21X.
MSC device cross-sectional view. No visual anomalies.
Arrow indicates shaped die for breakdown voltage enhancement.

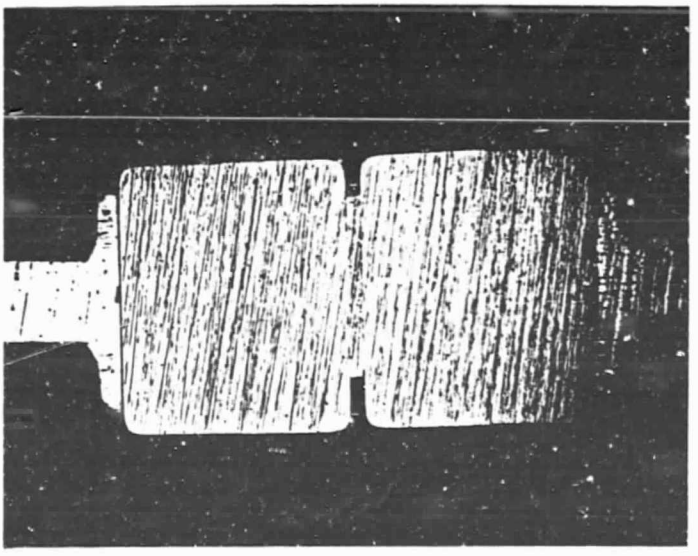


FIGURE A-2
S/N 1858. MAGNIFICATION 21X.
Unitrode device cross-sectional view.
No visual anomalies.

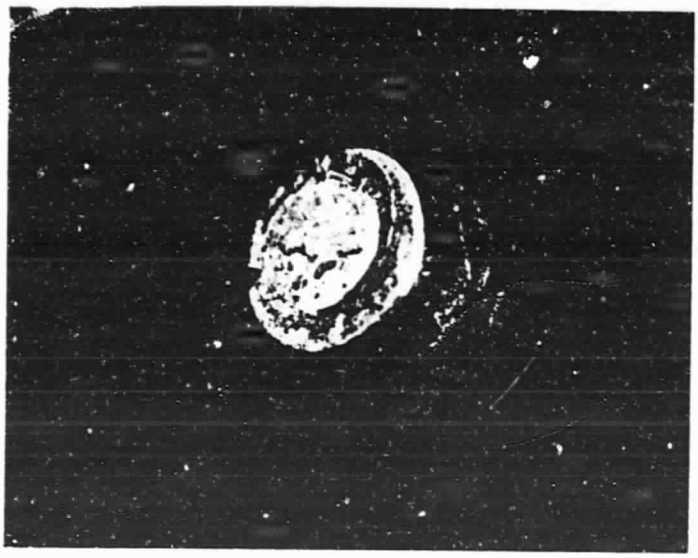


FIGURE A-3
S/N 1855. MAGNIFICATION 25X.
Separated joint where anode wire came off during burn-in. (Unitrode)